CONNECTION TO THE COSMOS

From Its Space-age Beginnings to Its 21st Century Programs, DARPA Is Intertwined with Space

By Stew Magnuson

During the summer of 2007, two spacecraft orbiting 492 kilometers above Earth carried out a series of complex maneuvers that marked several firsts in the history of space. DARPA's Orbital Express program demonstrated that a satellite – without human intervention – could capture and dock with a malfunctioning spacecraft, swap out faulty components and dead batteries, perform refueling, and carry out basic repairs.

The series of experiments marked another triumph for DARPA. Like the Space Age itself, the agency's roots reach back to the Soviet Union's launch of the Sputnik satellite nearly 50 years before on Oct. 4, 1957. Orbital Express showed that the agency – and space technology – had come a long way since then.

ARPA – THE BEGINNINGS

The 1950s were marked by both the fervor of the Cold War, when communism was seen as the No. 1 threat to national security, and a belief that American ingenuity and industry could overcome any technical challenge.

The incessant beeping transmitting from Sputnik changed that perception.

"When the Soviet Union demonstrated apparently equivalent or perhaps better skill in technical areas, the American perception of the threat and the belief in science were married to produce genuine fear," noted an unpublished history of ARPA (as it was known then). Advisors in the Eisenhower administration downplayed those fears, but Congress and the public were having none of it. The threat of a nuclear warhead being launched atop a missile was very real.

President Dwight D. Eisenhower wanted to avoid the "saber rattling" that would spark an arms race. The Defense Department's (DoD's) efforts to launch its own intercontinental ballistic missile remained classified and out of public view for just this reason. Nevertheless, the president acknowledged that the nation had to respond. By early November, the Soviets launched Sputnik II, containing the ill-fated dog Laika. This only served to ratchet up the public's fear even further.

DARPA's Orbital Express program demonstrated the capability of repairing and refueling satellites in orbit without human intervention. Here, Boeing technicians perform a post-integration inspection of the two Orbital Express satellites at Astrotech Space Operations in Titusville, Fla.

Photo courtesy of Ball Aerospace

The launch and orbit of Sputnik in October 1957 caused an uproar in America. If a satellite could orbit in space over the country, many Americans reasoned, then why not a nuclear warhead? In many ways, Sputnik was the spur for the creation of what was then known as ARPA.

NASA photo

Suspicions among the services that Sputnik had done more than emit a series of beeps – that it had some sort of secret reconnaissance mission – remained high. Dr. Herbert York, ARPA's first chief scientist, said it "was a crucial psychological landmark in the course of postwar arms development … everyone was shocked and the reactions of the sophisticated and the unsophisticated differed only in degree."

The Advanced Research Projects Agency would be among the first reactions to this "shot heard 'round the world."

Eisenhower addressed a wary nation on radio and television: "The world will witness future discoveries even more startling than that of nuclear fission. The question is: Will we be the ones to make them?" The administration's answer was to overhaul the government's approach to research and development. Without considerable investments in basic research, the nation's military technology would lag, it was believed. It's doubtful that DARPA would exist as it's known today if not for the efforts of three men: President Eisenhower, Secretary of Defense Neil McElroy, and the agency's first director, Roy W. Johnson.

Eisenhower, the retired general, was a vocal critic of the way the services did business. He publicly lamented the interservice rivalries and duplication – sometimes triplication – of weapon programs, which was the case for military space at the time of the Sputnik launch. The Army, Navy, and Air Force were all pursuing separate space programs.

McElroy was sworn into office only five days after Sputnik I. His predecessor, Secretary Charles E. Wilson, had consistently called satellites "scientific boondoggles," although his opinion did not stop the services from pursuing their space programs. They had powerful allies on Capitol Hill ready to provide the funding for pet projects such as rockets and satellites.

As the federal government debated how to respond to the Soviet launches, Eisenhower's newly appointed science adviser, James R. Killian, Jr., and McElroy began promoting the idea of a research agency that would restore the United States' perceived shortcomings in basic research. Eisenhower gave the idea his full support. McElroy and the administration began searching for ways to fund and organize the agency without congressional approval. Going around Congress was absolutely necessary, as it turned out, because as soon as the idea was floated, the services and their lawmaker allies began a vocal campaign to squash the idea. Formal protests, harshly worded memorandums, and intense lobbying followed, with the secretaries of the Army and Air Force leading the charge.

On Jan. 9, 1958, Eisenhower went straight to the American people and made his case in the State of the Union address.

"I am not attempting today to pass judgment on the charge of harmful service rivalries. But one thing is sure. Whatever they are, America wants them stopped," he said. Real reform was on the way, he promised, and the first step would be an agency that consolidated all anti-missile, rocket, and satellite technology programs into one organization.

The administration and Congress wrestled for another month over the legal ramifications of having the secretary of defense unilaterally initiate a program that would answer to his office, not the services. On Feb. 7, 1958, the secretary issued a directive and the agency was formally born. ARPA's role as the nation's sole space agency would be brief – about seven months – and its role as the DoD's executive agent for space would last only 22 months, but its impact would be profound.

PRIORITIZING SPACE

In the months preceding ARPA's creation, the services continued to run their own internecine space race. The Army's Redstone missile program, the Air Force's Thor series, and the Naval Research Laboratory's Vanguard rocket were in heated competition. For the time being, the Army could claim victory when, on Jan. 31, 1958, a short week before the establishment of ARPA and four months after Sputnik, one of its Redstone rockets sent the 23-pound Explorer I into orbit.

One of ARPA's first missions was to sort out the hodgepodge of programs. The man appointed to sort out the duplicated programs was Roy Johnson.

Like McElroy, Johnson came from the world of business. He was a 52-year-old General Electric (GE) executive with a solid reputation as a troubleshooter. He had no background in science or research and had never served in the government. An unpublished history of ARPA written in the 1970s called him an "utterly confident, calm, strikingly handsome individual who looked every bit like a *Fortune*-cover tycoon."

McElroy believed the director job should go to a seasoned manager rather than a technologist. Johnson's management style was progressive, and he commanded the loyalty and respect of ARPA's first employees. He made it clear that he had an open-door policy and was ready to hear complaints no matter how trivial. He encouraged the airing of differing opinions. He took the heat for failures, and shared the limelight when there was success. "The best boss I ever had," said one staff member. "I adored the hell out of him," said another.

His one overwhelming attribute, the history stated, was "complete frankness, whatever the consequences." His blunt opinions would soon ruffle feathers, but as GE's chief troubleshooter, he was prepared to do battle. The first order of business was sorting out the service's ongoing programs.

The Air Force, at the time of the Sputnik launch, was in the beginning stages of developing a spy satellite, which was code-named Janus. In an early example of what is known today as "requirements creep," plans called for packing the satellite with a camera, electronic sensors to detect emissions in the electromagnetic spectrum, an intercontinental ballistic missile detector, and a capsule recovery feature that would allow for in-orbit experiments on primates. The program would also attempt to deal with basic functions such as attitude control, propulsion, guidance and control, communications, and data processing. And Janus was only one example of what the services were attempting.

"The number of proposals was enormous," said York. "The confusion that these proposals created was very great, and the solution to pull it together at a higher level was probably a good one because interservice rivalry was able to feed off that kind of confusion. ... It was a mess. It really was."

McElroy ended the interservice rivalries and transferred all military space projects to ARPA management on Feb. 7, 1958.

Johnson had to quickly put together a staff. Adm. John E. Clark, his deputy, came from the Navy. York, former director of the Livermore Radiation Laboratory, took the position of chief scientist. Johnson began recruiting scientifically minded military officers, civilian agency counterparts, and engineers from top corporations. The salaries were low, but patriotism and a sense of urgency prompted many to join the effort. Many of these early staff members were so-called "space cadets." They fervently believed that the future lay beyond Earth's atmosphere. While Johnson came to ARPA with no background on the subject, he was a quick study, and he soon embraced their beliefs.

As one staff member put it, ideas were coming into the office "by the bushel." Johnson served as the arbitrator on which projects would receive the green light. However, he didn't win early debates on whether ARPA would run its own facilities. There was talk that it would take over the California Institute of Technology's Jet Propulsion Laboratory, which was then an Army contractor. That never happened. And neither would ARPA have its own dedicated labs. Instead, it would farm work out to the services, contractors, and research laboratories.

ARPA had other missions besides space – for example, ballistic missile defense. But Johnson devoted little time and resources to anything other than launching satellites. Meanwhile, the services continued to bombard ARPA with "requirements." The military officials were either fans of science fiction or had active imaginations. Armed anti-satellite systems, space patrol vehicles, manned maintenance and resupply spacecraft, a military space logistics base, even interplanetary ships were just a few of the high-flying concepts. The Army proposed a "space-to-Earth" weapon system and wanted to establish a manned moonbase in order to take the "ultimate high ground" before 1965, according to the book *The Rocketmakers* by Harry Wulforst. The Navy envisioned launching satellites from aboard ships.

Other requirements were more reasonable. They would one day be recognizable as today's space architecture: strategic surveillance; signal intelligence; and navigation, communications, and meteorological satellites.

While the services didn't lack imagination, ARPA did lack funds. To accomplish all these requirements at once was neither technically feasible in a field still in its infancy, nor possible to pay for with an annual budget of about $520 million in fiscal year 1959.

Many of these high-flying concepts, of course, would one day become reality – particularly the notion of manned spaceflight. Meanwhile, ARPA came up with a strategic plan to prioritize these potential space missions as work continued at a rapid pace to "achieve the achievable." Projects were divided into military and non-military scientific programs. Many of these were not as "advanced" or "far out" as the agency's name suggested. Studies on the feasibility of reconnaissance satellites, for example, had been ongoing since the 1940s.

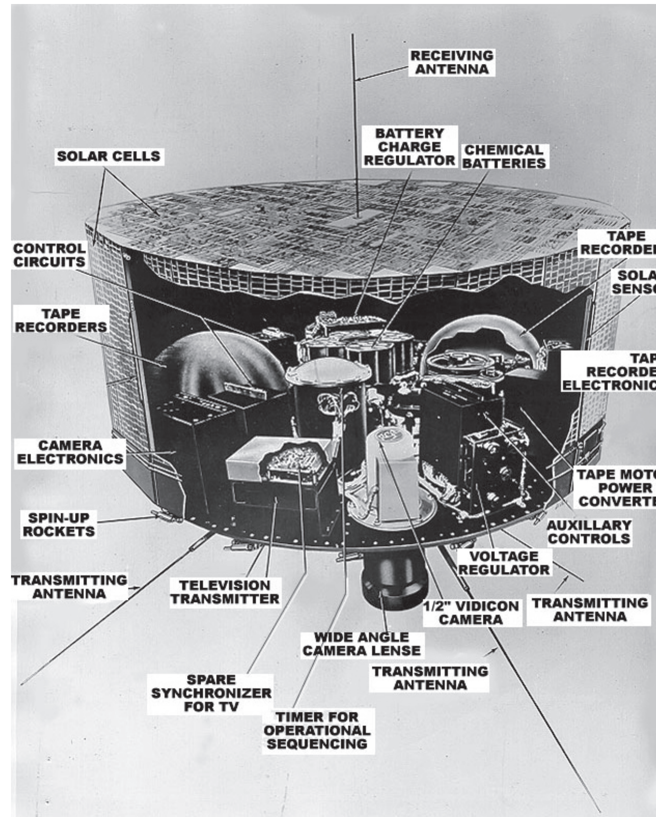
The first order of business was to transfer the overly ambitious Janus program from the Air Force to ARPA management and divide its missions up into three separate projects. The Sentry project, later called Samos, would demonstrate reconnaissance capabilities. Midas was set up to detect ballistic missiles with infrared sensors. Discoverer was a technology test bed that would iron out problems such as stabilization and attitude control, injection into space, and capsule recovery. Discoverer and Samos would evolve into the classified Corona program and provide the first space-based intelligence photos. Also doable in the near term was a fourth offshoot of the Janus program, the Tactical Cloud Cover Satellite program, later known as TIROS – the Television Infrared Observations Satellite. It would become the first weather satellite and ARPA's earliest success story.

ARPA wanted to put a man in space from the beginning. It was assumed that the Soviets were working toward the same goal and the assumption was right. The nation had been beaten once and it didn't want to be beaten again. Johnson may have put the brakes on the notion of establishing a manned moonbase, but he was convinced that service members should be stationed in low-Earth orbit.

Eisenhower shared a vision for placing Americans in orbit, but only for peaceful purposes. Powerful Texas Sen. Lyndon B. Johnson and Eisenhower firmly believed in the creation of a civilian space agency, and while Roy Johnson was a formidable advocate for military space, he could never hope to trump that pair. In fact, the President's Science Advisory Committee was already laying the groundwork for the National Aeronautics and Space Administration's creation before Roy Johnson began his first day of work. A second DoD office, that of the Director of Defense Research and Engineering, was also in the works and would soon take away some of ARPA's authority.

Prioritizing the service's space wish lists angered military leaders and few of the generals and admirals were happy with Johnson's decisions. What's more, Johnson began characterizing ARPA as the "fourth service" in research and development. Naturally, this did not sit well with the Army, Navy, and Air Force. But Johnson was undaunted. His subordinates described him as a man who was unafraid to sit in a room full of highly decorated officers and tell them what he thought.

A paper written by two of Johnson's staff members laid out his belief: "With the scientific-military aggressiveness the USSR has already demonstrated, it would be a fatal mistake to underestimate the military importance of space operations. As a nation, we are in deadly contest for our survival with Russia. Thus the major purposes of space vehicles will be shaped by their military requirements."



The TIROS satellite was ARPA's first triumph in space, and TIROS 1 alone took more than 19,000 photos used in weather analysis.

National Oceanic and Atmospheric Administration photo

TIROS MARKS A FIRST

As the debates over ARPA's roles continued, the new office was breaking ground on the technical side. The TIROS program was the agency's first triumph.

TIROS 1, launched from Cape Canaveral on April 1, 1960, immediately proved the viability of observing the weather from space, according to the *USA in Space* reference book by Frank N. Magill and Russell R. Tobias. It took 23,000 cloud-cover pictures, of which more than 19,000 were used in weather analysis. For the first time, meteorologists were able to track storms over the course of several days.

The project became a model of how scientists and engineers from different services, federal agencies, and contractors would come together to solve vexing problems. The project officer, Dr. Roger S. Warner, showed "exceptional skill … in getting scientists and engineers of diverse backgrounds, temperaments, to work together," the unpublished history of ARPA stated. Rand Corporation, television manufacturer RCA, the Army's Ballistic Missile Agency and Signal Corps, the Air Force, and the Weather Bureau were among those on the team. The program was later passed on to NASA, which would launch nine more satellites. TIROS would serve as a model for how to put together diverse groups and quickly achieve a complex technical feat.

A less glamorous but nonetheless important mission came when Eisenhower ordered that ARPA investigate ground-based Doppler radar to locate and track the Soviet Union's future Sputniks. This would lay the groundwork for today's space surveillance architecture. In addition, four communications satellite programs, collectively known as NOTUS, would also have their origins during ARPA's tenure as the executive agent for space.

The agency under Johnson's leadership also gave the green light to what would become the first navigation satellite. The Navy was keen to attain this capability for its fleet of ships and Polaris submarines. The concept for the constellation of satellites came from Johns Hopkins University's Applied Physics Laboratory, and ARPA handed all the work over to the lab in October 1958. The Transit Navigation System program launched five satellites between 1960 and 1961, and it immediately proved the value of providing precise coordinates on the seas. Their successors would remain in orbit and functioning until 1996, when the more precise Global Positioning System would take over.

ARPA also made crucial decisions in launch technology that would affect the nation's space capabilities throughout the 1960s. Its early support of the Army's Juno rocket program, which was conceived by the von Braun team, would eventually evolve into NASA's Saturn family of rockets.

ARPA also put its resources into the as-yet-unproven Centaur high-energy, liquid-hydrogen, liquid-oxygen launch vehicle. It proved to be a good bet. It was later wed to an Atlas rocket and went operational in 1966. Saturn, like TIROS and the Centaur programs, would be transferred to the civilian space agency, which would receive the

Following DARPA's initial development and demonstration of the Pegasus rocket, Pegasus has been used to launch 38 small satellites through 2007. Pegasus is pictured here mated to the NASA B-52 mother ship on its first launch.

NASA photo

accolades. ARPA's early involvement in these programs is rarely highlighted in history books.

ARPA LOSES CONTROL OF SPACE

Most of ARPA's early successes were not the "advanced" or "far-out" concepts that are associated with the agency today. It inherited satellite and rocket programs from the services that were already under development. It was looking outward, though – most notably in the field of manned spaceflight.

As ARPA piled up early successes, debate continued on the nation's future in space. From day one of the agency's existence, forces were working on the creation of a civilian space agency. While the space race with the Soviet Union was definitely on, there were many, including Eisenhower, who didn't want to couch the rivalry in military terms. His administration, Sen. Johnson, and the State Department were all in favor of a civilian agency. Most acknowledged that there would be unique military requirements for space.

ARPA Director Johnson, in a Capitol Hill hearing, harshly criticized the NASA bill. He believed that the military needed to control its own space program. "The legislation setting up a civilian group should not be so worded that it may be construed to mean that the military uses of space are to be limited by a civilian agency. This could be disastrous. It behooves the writers of this legislation to state positively this freedom clearly and without equivocation.

"For example, if the DoD decides it to be militarily desirable to program for putting man into space, it should not have to justify this activity to this civilian agency."

Dr. Steven Walker, program manager of DARPA's Falcon program, believes that the "future of spaceflight lies in reusable launch-on-demand technologies ... which are free from launch pad restrictions." DARPA's notional Falcon Hypersonic Cruise Vehicle, rendered here, could potentially provide such aircraft-like capabilities to spacecraft.

Johnson would lose this battle. The services would not send soldiers or Marines into space. However, the bill would eventually allow the DoD to keep its unique programs.

The White House was not accustomed to one of its employees publicly airing his differences. Johnson also waged a bruising battle with the administration over the heavy launcher programs. For Johnson, large multi-stage rockets were symbolic of the military versus civilian space debate. The administration believed that the military didn't need to venture farther than 600 miles beyond Earth. Johnson disagreed. He lost that fight as well, and resigned shortly after. The Juno booster program would be rechristened Saturn and move to NASA, although Johnson would one day be proven right. The military would need to launch satellites into higher orbits.

After NASA took the helm of the scientific and manned mission, ARPA's existence nearly came to an end. Many, including its longtime critics in the services, questioned the need for a separate military space agency. ARPA in its prime returned 80 percent of the programs back to Air Force management, they argued.

The Department of Defense Reorganization Act of 1958 created the Defense Research and Engineering Office, and put ARPA under its control. ARPA's chief scientist, York, became its first director in December 1958.

In the end, the Air Force received its wish. McElroy made the Air Force the executive agent for space on Sept. 18, 1959. Johnson left in November 1959, but never ceased to believe that the military needed to play a key role in space. He was convinced that the services should continue to develop mature technologies, but that cutting-edge programs should be left to ARPA.

That vision would endure – as would ARPA itself.

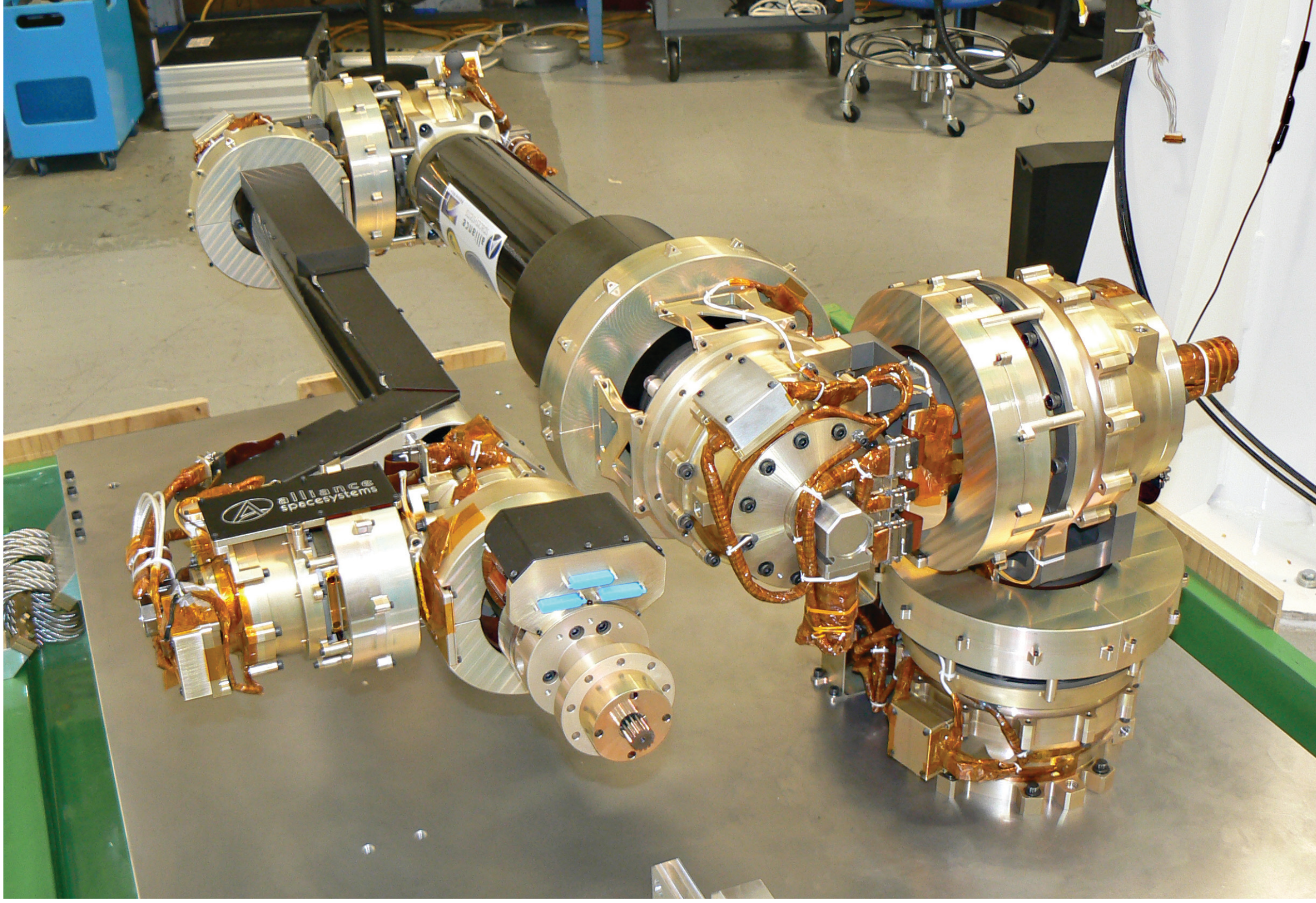
PROJECT VELA

ARPA's role in space was severely diminished, but it did not entirely leave the business. By the early 1960s, it would be called upon to monitor nuclear detonations in remote areas.

Even before the U.S. Senate ratified the Partial Test-Ban Treaty in 1963, the U.S. Arms Control and Disarmament Agency recognized the need to verify that the Soviet Union and other nations would comply with its terms. Project Vela – "watch" in Spanish – would be the classified network of sensors designed to verify compliance. Ground-based sensors couldn't adequately cover the Earth, so a global satellite system that could seek out nuclear detonations and the X-rays, gamma rays, and neutrons they produced – particularly in the upper atmosphere – was needed. It was hoped that it would eliminate the need for costly ground-based monitoring systems.

Work at ARPA on Vela-Hotel, or Vela-H, the code name for the satellite portion of the sensor network, had begun as early as 1959. Ratification of the treaty accelerated the program because it would ban nuclear detonations in the atmosphere, underwater, and in space. The joint Department of Energy – DoD project got under way as diplomats hammered out the details of the treaty.

Image courtesy of DARPA



DARPA's Front-end Robotics Enabling Near-term Demonstration is essentially a "space tow truck" that will perform in-orbit servicing of satellites.

Photo courtesy of DARPA

The program had a daunting challenge: detect nuclear explosions as small as 10 kilotons from the Earth's surface to as far as 160 million kilometers from Earth, according to *USA in Space*.

ARPA and its partners, Los Alamos National Laboratory, Sandia Corporation, and contractor TRW, under ARPA's leadership, married the sensors to the satellite. The program delivered on its promise in the nick of time. Great Britain, the Soviet Union, and the United States came to an agreement and the ban went into effect Oct. 10, 1963.

An Atlas-Agena rocket launched the first pair of Vela satellites only seven days later. The spacecraft – using an onboard engine – eventually reached a 110,868-by-101,851-km orbit, roughly one-quarter of the distance to the moon. This was a record for a military satellite. The two satellites were positioned 180 degrees apart and pointed in opposite directions in order to gaze at Earth and space.

The second pair of Vela satellites detected the first atmospheric test conducted by the People's Republic of China in October 1964.

Following the Vela project, ARPA space research and development programs didn't re-emerge for nearly four decades.

ARPA GETS BACK INTO SPACE

In 2001, Dr. Anthony J. Tether sat before newly appointed Defense Secretary Donald Rumsfeld, who was conducting a job interview for the director of DARPA. Rumsfeld told Tether that he wanted the agency to get back into the space business.

Since the 1960s, ARPA, now rechristened the Defense Advanced Research Projects Agency (DARPA), had moved on to make great advancements in other fields, but its space research and development programs had languished. Some small projects had continued. For example, DARPA provided funding to Orbital Sciences Corporation to jump-start its Pegasus rocket program. The winged rocket, first launched from a B-52 in 1990, would go on to conduct 38 successful launches of small satellites through 2007, but projects such as these were few and far between.

Prior to his appointment, Rumsfeld had chaired the Commission to Assess United States National Security Space Management and Organization, which published its findings in early 2001. Among the recommendations was a call for the nation to invest more resources in military space technology.

Space systems had helped transform the military, and it used these orbital assets to communicate, navigate, and peer down on potential enemies. But these great capabilities also meant great vulnerabilities. The U.S. military depended on space, and adversaries could use that knowledge to their advantage. There was also great dissatisfaction within the DoD with how space systems were acquired. New programs were coming in late and over budget. What's more, the per-pound cost of launching spacecraft was too high, many believed.

DARPA would tackle some of these problems. "It was the commission report in 2001 that launched us back out into space," said Tactical Technology Office Deputy Director Dr. Steven Walker. "Rather than react to surprising events of the future, we decided that flexible space architectures should be designed now, so that we would be prepared for future asymmetric threats in space," Walker said at the 2007 DARPATech conference. "We need space capabilities that are more responsive, more robust, and can be modified easily as threats arise," he added.

DARPA's space budget has swelled to about $500 million per year under Tether. The agency has identified five strategic space focus areas: Access and Infrastructure; Space Situational Awareness; Space Mission Protection; Space-based Support of the Warfighter; and a classified area called Space Mission Denial. The large – what some have called "monolithic" – satellites are marvels of modern engineering, but they take five to 10 years to develop, build, and launch. As satellites are being constructed, technology advances and makes some of their components outdated as soon as they reach orbit. This realization has led to a movement within the military community known as Operationally Responsive Space, which is defined as the ability to bring the capabilities of space assets to battlefield commanders "on demand." Part of that vision is the ability to rapidly replace satellites that are lost due to malfunction, or in a worst-case scenario, an anti-satellite attack.

"Flexibility and the technology that enables it is the cornerstone of DARPA's vision of a new space architecture," said Owen Brown, a program manager, at the 2007 DARPATech conference. Satellites today "are configured to solve tomorrow's problems using yesterday's technologies," he added.

DARPA has demonstrated two launch programs under its Falcon program that it hopes will send a small payload – 1,000 pounds or less – into low-Earth orbit within 24 hours and for less than $5 million. DARPA and the Air Force funded two test flights of the Falcon 1, a two-stage, liquid oxygen-kerosene rocket manufactured by a start-up company, Space Exploration Technologies. The first launch on March 24, 2006, ended in failure, but the second on March 20, 2007, from the U.S. Army Space and Missile Defense Command Reagan Test Site at the Kwajalein Atoll in the South Pacific, reached an altitude of 200 miles. As was the case with Orbital Sciences, DARPA's support for the demonstrations has allowed the company to commercialize its technology and it is slated to provide commercial re-supply of the space station for NASA.

Another start-up space firm, AirLaunch LLC, is developing the QuickReach small launch vehicle under the Falcon program, which will drop a small rocket from the back of a C-17 transport aircraft. Walker said the future of spaceflight lies in reusable launch-on-demand technologies such as QuickReach, which are free of launch pad restrictions. The Falcon Hypersonic Cruise Vehicle program, still in its infancy, may one day provide aircraft-like capabilities for spacecraft.

Space mission protection was addressed in the Orbital Express demonstration in the summer of 2007. "The Orbital Express program did an outstanding job of demonstrating fuel transfer, battery transfer, from one satellite to another autonomously," Walker said. "We believe we've demonstrated the capability, and now it's a matter of convincing others that it is worth putting on future satellites to extend their life."

DARPA and the Naval Center for Space Technology are currently working on the next in-orbit servicing program. A "space tow truck," the Front-end Robotics Enabling Near-term Demonstration, may prove that a space vehicle can grapple a malfunctioning satellite and transfer it to a different orbit where it can perform better, or remove large pieces of space junk from key orbits so the junk doesn't harm other satellites.

ANOTHER SHOT HEARD 'ROUND THE WORLD

On Jan. 11, 2007, China launched a rocket at one of its own defunct weather satellites in low-Earth orbit and demonstrated the ability to knock spacecraft out of the skies.

As Sputnik had nearly five decades ago, this anti-satellite (A-Sat) test served as a wake-up call in the military space community. But DARPA had been addressing a potential "space Pearl Harbor" scenario for years, Dr. Brian Pierce, deputy director of the Strategic Technology Office, pointed out.

"China's destruction of this satellite vividly demonstrated the vulnerability of space assets – the satellites that our military relies

A 65-foot, 72,000-pound booster rocket mock-up exits the cargo bay of a C-17 Globemaster III. The airdrop was the final test in phase 2B of the Falcon small launch vehicle program, a joint effort between DARPA and the Air Force to develop a more flexible and low-cost method of putting a 1,000-pound satellite into low-Earth orbit. This was the longest and heaviest single item ever dropped from a C-17. The program aims to make space launch of satellites and other small payloads both faster and more affordable.

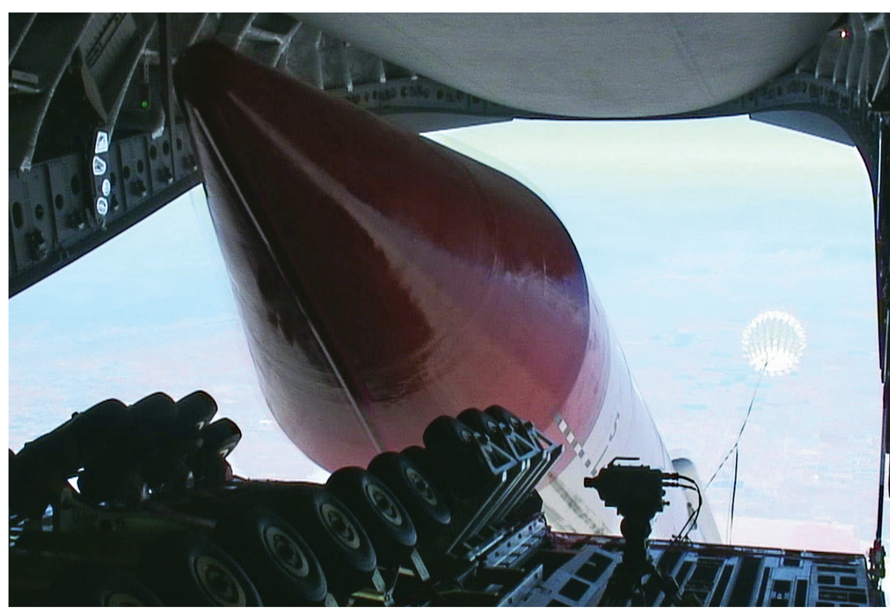
on for navigation, communications, and sensing ... There is no longer any excuse not to take notice," he said at the 2007 DARPA-Tech conference.

In the wake of the A-Sat test, Space Situational Awareness became a priority for the Air Force. The need to track potential "killer" satellites, along with so-called space junk and space debris, is the focus of two ground-based sensor programs. Long View is developing an inverse synthetic aperture laser radar that, when coupled to a large telescope, will provide high-resolution images of geostationary satellites 22,000 miles above the Earth.

"If we can do space situational awareness from the ground, then we can get a lot of cost savings," Pierce said in an interview.

Space debris, solar storms, and the threat of an adversary destroying a satellite have given rise to an ambitious DARPA program that may one day replace large, monolithic satellites.

The F6 program – Future, Fast, Flexible, Fractionalized, Free-Flying Spacecraft United by Information Exchange – would launch small satellite components into space, with each performing a separate function. For example, a remote sensing camera node, an on-board computer processing node, and a communication node would orbit nearby and be linked wirelessly. If one node failed, a



Photos by Steve Zapka

replacement could be launched to replace it. This would be less expensive than replacing an entire 10,000-pound satellite. An F6 system performing remote sensing could be reconfigured to be a communications satellite by sending up a new component.

"F6 is all about taking the capability of one of our monolithic satellites that we would acquire today and splitting that up into small modules that can be put together or launched individually on small launch vehicles," Walker said. This concept goes hand-in-hand with the Falcon Small Launch Vehicle program, he added. The need to protect space assets may also require the more vulnerable low-Earth orbiting satellites to be moved into higher orbits. That may mean sensors will have to become more sensitive, Walker said.

"After the January Chinese A-Sat test, we have spent more time at DARPA thinking about how to enable the same capability for on-orbit assets we have at [low-Earth orbit] for higher orbits. We are thinking along those lines much more than we did before that test."

Fifty years after Sputnik's launch, space continues to change, Walker noted. More than 40 nations have assets in space. And one day, a commercial sector will rise up to put ordinary citizens into orbit. "That's going to change space dramatically," Walker said, and added that protection of our assets and space situational awareness will be even more critical.

DARPA's ongoing challenge will be to develop the cutting-edge technologies that will maintain the U.S. military's superiority in space for the next 50 years.